Wireworms and their control on irrigated lands

Farmers' Bulletin No. 1866

U. S. DEPARTMENT OF AGRICULTURE

CONTENTS

Wireworms Discussed

Sugar-beet wireworm (*Limonius californicus*)
Pacific coast wireworm (*L. canus*)
Western field wireworm (*L. infuscatus*)
Columbia Basin wireworm (*L. subauratus*)

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WIREWORMS AND THEIR CONTROL ON IRRIGATED LANDS

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THE CONTROL OF WIREWORMS by chemical methods saves millions of dollars annually to growers of vegetable and field crops in the irrigated lands west of the Rocky Mountains.

Wireworms are the young of click beetles. They are easily recognized by their shiny, wirelike, yellow to orange bodies, and by their habit of feeding only on the underground parts of plants. There are many kinds of wireworms, but the four causing the most damage in irrigated lands are the sugar-beet wireworm, the Pacific Coast wireworm, the western field wireworm, and the Columbia Basin wireworm. Other kinds of wireworms, with different habits and life histories, cause limited damage in these areas, and may or may not be controlled by methods recommended here.

These four wireworms are native to the region, but before irrigation was undertaken they were found only in naturally damp soils near streams and lakes. Irrigation created soil conditions favorable for wireworms, and they became abundant in fields that were irrigated throughout the dry season, especially in those planted to truck and field crops. They also occasionally cause damage on the more intensively cultivated lands in the wet coastal belt west of the Cascade Mountains.

No crop is known to be entirely free from attack, but potatoes, corn, onions, lettuce, melons, beans, tomatoes, peas, carrots, and sugar beets are particularly susceptible to injury.

NATURE OF INJURY

Wireworms may damage crops in two ways. They may destroy seed and seedlings, and they may injure the bulbs, roots, and tubers.

Destruction of Seed and Seedlings

Early in the season, and sometimes late in the summer, newly planted beds are destroyed, or the young plants are cut off just under the soil surface so that replanting is necessary (fig. 1). More damage may be expected during cool, moist weather than in hot, dry periods, when the wireworms move deeper into the soil.

Injury to Bulbs, Roots, and Tubers

Later they tunnel or scar the maturing tubers, roots, and bulbs, making a large part of the crop unfit for marketing (figs. 2, 3, and 4).

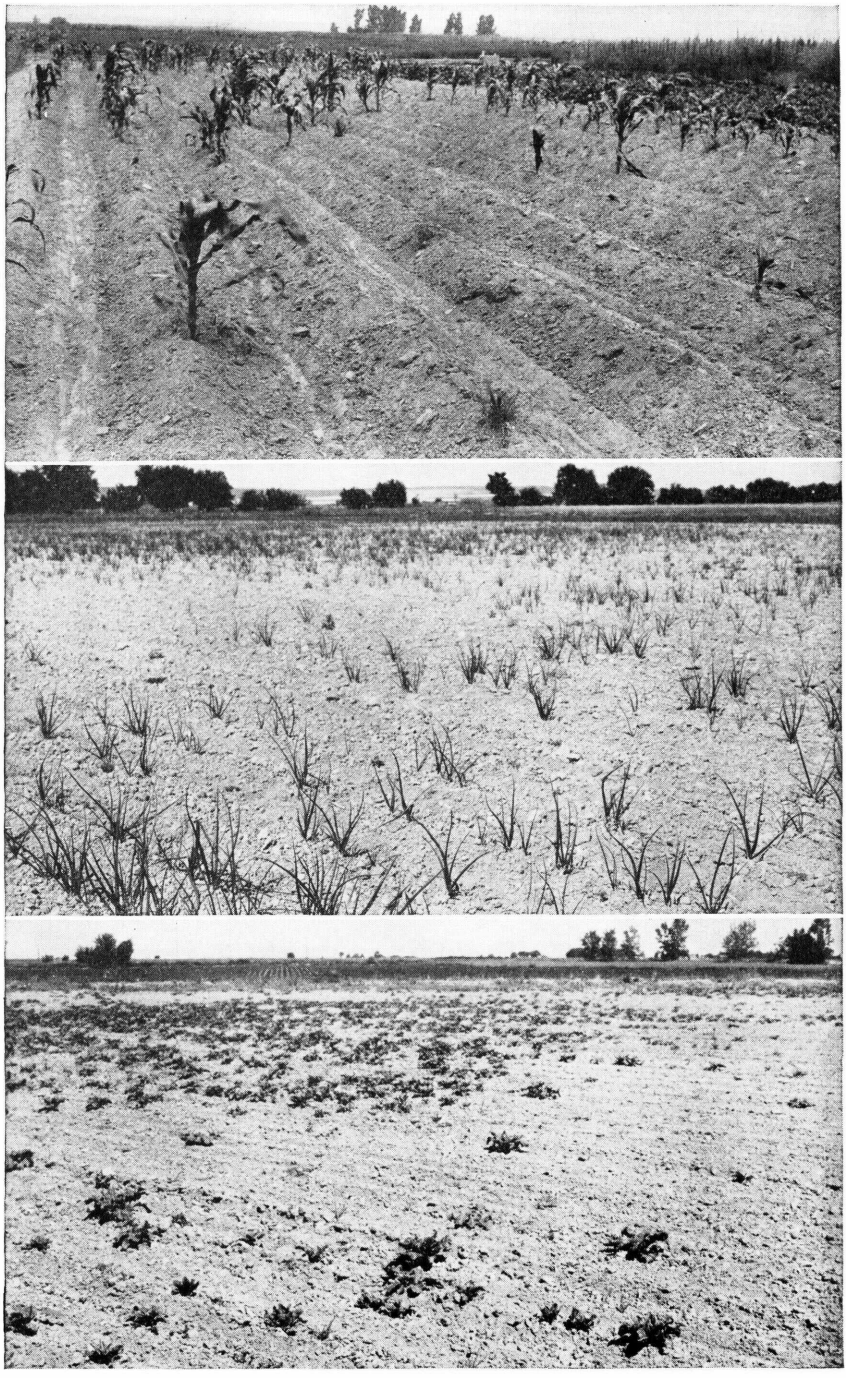

Figure 1.—**Fields of corn, onions, and sugar beets damaged by wireworms.**

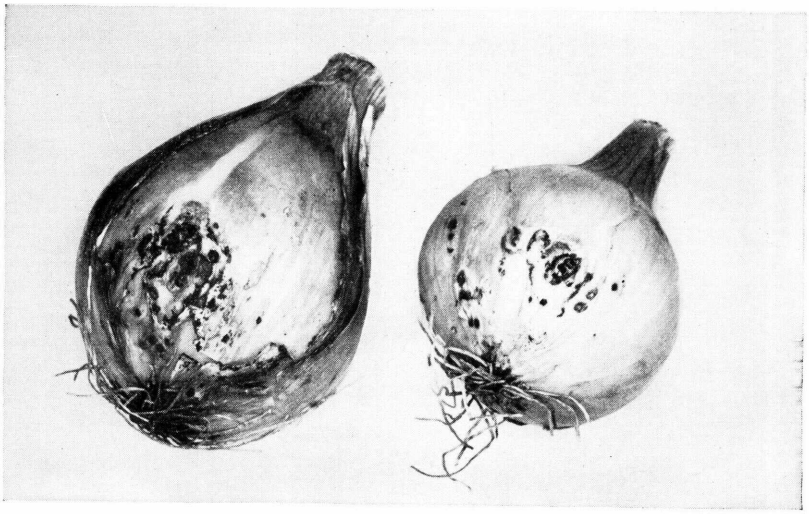

Figure 2.—Onion bulbs with holes made by wireworms.

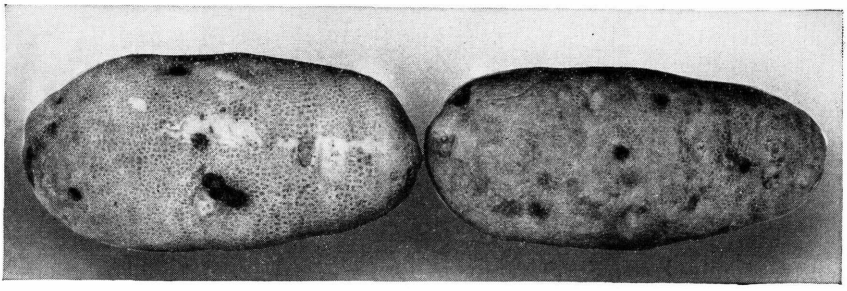

Figure 3.—Scars on late Netted Gem potatoes made by wireworms.

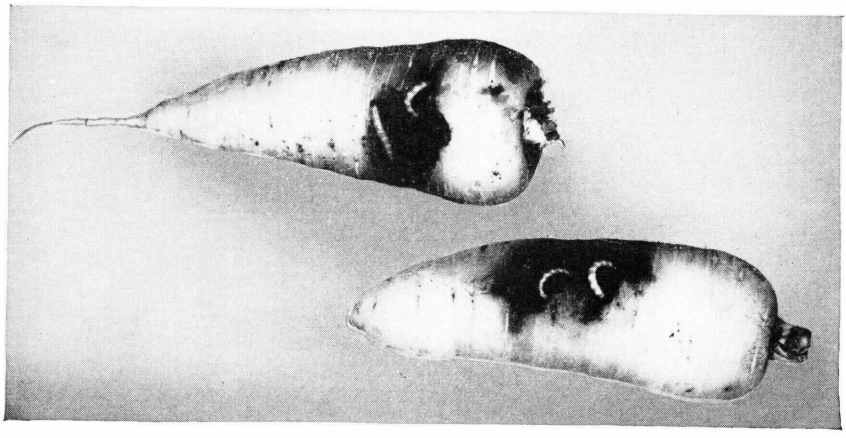

Figure 4.—Wireworms feeding on carrots.

This damage causes the greatest financial loss to the farmer. A crop that has survived all the attacks of other insects and diseases may be found at harvesttime to be practically unsalable on account of wireworm damage.

The high cost of irrigation farming necessitates a crop-rotation system that includes at least one cash crop each year. Potatoes, onions, and carrots are often grown for this purpose, and they have to be graded under Federal or State standards before they are marketed. Wireworm damage often prevents many of the tubers, bulbs, or roots from passing these grades, and makes them fit only for stock feed (fig. 5).

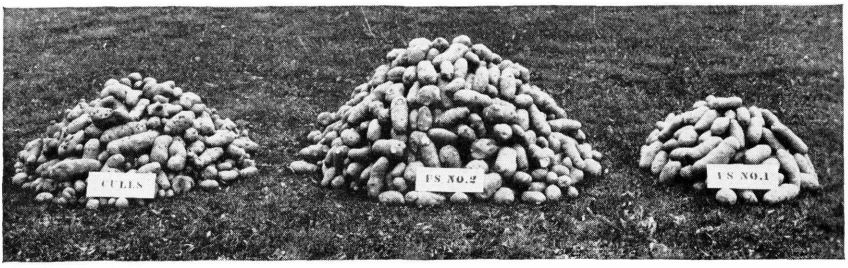

Figure 5.—**Grades of potatoes showing reductions caused by wireworms.**

ESTIMATING POPULATIONS

A farmer should learn something about the number of wireworms in his field before planning the season's operations. With this information he can decide what crops to plant to avoid wireworm damage. And if the infestation is heavy, he can fumigate or otherwise treat the field. Simple soil-sifting equipment (fig. 6) can be constructed for use in estimating wireworm populations.

A simple shaker and sifter combination can be made from the usual odds and ends around the farm workshop. The shaker can be fashioned from a piece of ¼-inch spring steel, 36 inches long, with a one-quarter twist near the base, fastened into the long arm of a T-shaped base of a 2- by 6-inch wooden plank. A suitable cross arm of spring steel with a bend in one end is welded to the top of the upright to hold the screen sifter frames. Frames from 18 to 24 inches square can be made from ¾- by 3-inch wood. Ordinary 4-mesh hardware screen should be tacked tightly on one frame and 8- to 16-mesh window screen on the other.

The soil from test holes is passed first through the 4-mesh screen, which breaks up the soil and gets rid of the debris. The shiny, yellow wireworms are readily found in the residue on the 8- to 16-mesh lower screen.

Twenty well-scattered test holes, made a foot deep with a 6-inch posthole auger or an irrigation shovel, should be enough per acre. If no wireworms are found in the 20 test holes, it should be safe to plant any crop. If as many as 5 wireworms are found, considerable damage can be expected, particularly to beans and potatoes, and if 10 or more are found, the damage may be severe.

Figure 6.—Hand sifter and posthole auger for use in determining wireworm numbers in fields before planting.

DESCRIPTION

Eggs

Wireworm eggs are pearly white and only slightly longer than wide. They are very small, measuring only about $\frac{1}{50}$ inch long, and are very difficult to see in the soil. The eggs dry out if exposed to the air for more than a few hours.

Larvae

The newly hatched wireworms, or larvae, are white with dark jaws, and about $\frac{1}{16}$ inch long. After feeding and molting several times, they become hard, jointed, and shiny, and dark yellow in color (fig. 7). They have three pairs of legs, and the last segment of the body is pronged or forked behind. Wireworms ordinarily found in the soil may be $\frac{1}{4}$ to $\frac{3}{4}$ inch long. It is in this stage that the insects feed, and damage the roots of crops.

Pupae

The pupae (fig. 7) are white and so delicate that they are easily injured by handling. They resemble the adult beetles, and become darker just before they reach the adult stage.

Adults

The adults (fig. 7) are slender, hard-shelled beetles, tan to very dark brown, and $\frac{1}{3}$ to $\frac{1}{2}$ inch long. They are popularly known as click

beetles or snapping beetles, from their habit of snapping the forepart of their bodies when held between the fingers or placed on their backs. The sexes are similar in shape, but the female is often lighter in color and usually more robust than the male. The antennae are somewhat shorter in the female.

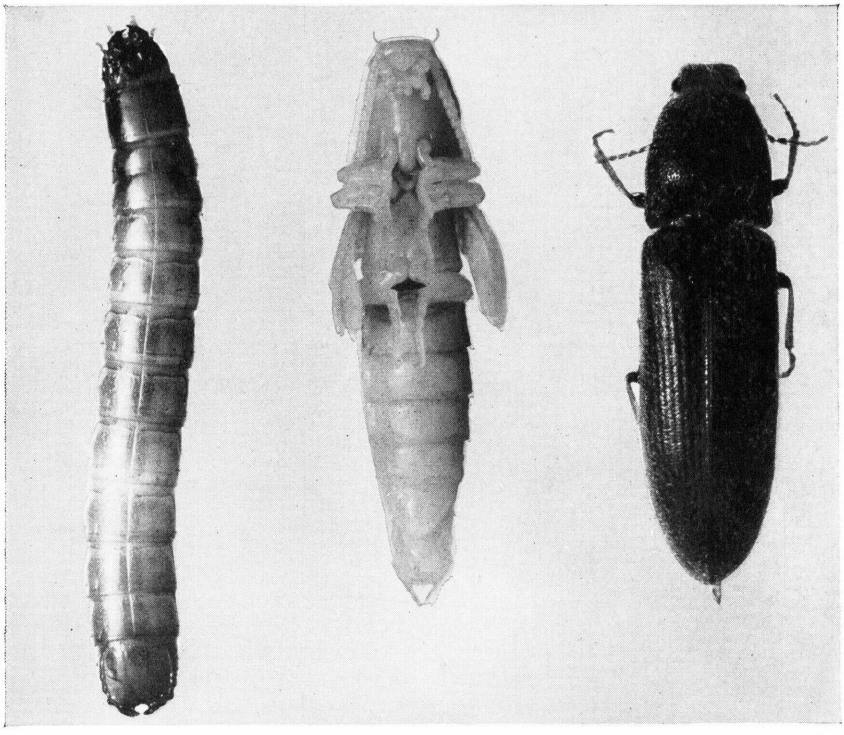

Figure 7.—**Stages of the sugar-beet wireworm: Left to right, full-grown larva, pupa, adult beetle. All enlarged.**

LIFE HISTORY AND HABITS

The adult beetles transform from the pupae in the summer, but do not emerge from their cells in the soil until the next spring, when the temperature in the top 3 inches reaches 55° to 65° F. In the warmer localities emergence begins about the first of March and extends to early in June. The beetles crawl about over the soil surface, rest on low vegetation, or make short flights near the ground on bright, sunny days. Food does not seem essential to the adults, although some species feed on early fruit blossoms, such as those of the cherry, peach, and pear.

Migration into new fields takes place only during the adult flight in the spring. The females fly very little until after they have laid most of their eggs, usually in the same field from which they emerged. Adults remain alive long enough to mate and lay their eggs. The entire period of adult life above the soil is usually not longer than 3 or 4 weeks.

Immediately after mating the female beetles burrow back into the soil and within a few days begin to deposit their eggs. These are placed singly, but close together, in damp soil from 1 to 6 inches deep. Each female lays from 50 to 300 eggs. Most of the eggs hatch in 3 or 4 weeks if placed in favorable locations.

The young larvae, on hatching, work their way through the soil in search of food. Mortality is heaviest during this early period, because of the difficulties the tiny larvae have in finding food and satisfactory soil conditions. They do little damage to field crops during their first season, but those that survive may do considerable damage the second season. They bore through the outer layers of seeds, stems, or roots and feed on the inner, more succulent portions. In fact, they swallow their food only in a predigested liquid form.

A few of the wireworms become adults in 1 year if food, soil, and temperature are favorable, but usually 2 to 5 years are required and, under unfavorable conditions, 6 or more years.

In California most of the wireworms in fields planted to a succession of crops annually mature in 2 years, but in fields with only one crop 3 years are usually required.

In the Pacific Northwest most wireworms take 3 years to complete their life cycle. Owing to an overlapping of generations, wireworms of all sizes and ages are present in the soil throughout any growing season.

The full-grown wireworm prepares to change into a beetle in July and August. It first makes a small cell from 3 to 8 inches below the surface of the soil. Here it sheds its last larval skin and becomes a naked white pupa. About 3 weeks later the pupa changes to the adult beetle.

SEASONAL MOVEMENTS IN THE SOIL

Wireworms start moving up toward the surface when the soil temperature reaches about 50° F., usually early in March in California and late in March in the Pacific Northwest. The number found near the surface increases gradually during April and May. In June, when the surface temperature reaches 80° and above, they move downward again. In midsummer most of them stay below the 6-inch level in the soil, except in fields that are densely shaded, as by alfalfa or potatoes. Some wireworms may move toward the surface in September, but the majority remain below the 6-inch depth during the winter. In the Pacific Northwest and in California soil temperatures never are low enough to winter-kill wireworms, either as adults or as larvae.

NATURAL ENEMIES

Wireworms have few natural enemies. Insect parasites and predators are practically unknown.

Birds sometimes feed on the larvae turned up by cultivation, and on the beetles during their period of emergence in the spring. However, it is doubtful whether birds would ever be an important factor in reducing the number of wireworms in irrigated lands.

There are a few fungus enemies of wireworms, but it is also doubtful whether these could be increased sufficiently to become important in wireworm control.

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TRAPS AND BAITS NOT ECONOMICAL

Baits

Research has shown that not over a third of the wireworms present in the ground at any given time can be attracted to baits. No poison has been found practical for use in baits to kill wireworms. Some common chemicals, such as arsenicals, are very repellent to wireworms. Baiting is laborious, and the expense of time, labor, and materials on a large scale is not justified.

Traps

Attempts have been made to trap adult beetles during the emergence period in the spring. The males can be attracted in some numbers, but the females apparently are not attracted to anything before they have mated and laid most of their eggs.

CHEMICAL METHODS OF CONTROL

The control of wireworms was a difficult problem until about 1946. Since they spend nearly all their existence beneath the soil surface, it was practically impossible to reach them with the older contact and stomach poisons. Some of the older soil fumigants were used but none was satisfactory until ethylene dibromide was found to give good control under a wide variety of conditions.

Since 1946 several insecticides have become available, which will control wireworms when mixed thoroughly with the soil. DDT has been most satisfactory.

For immediate control of wireworms, and if nematodes are a problem, it is best to fumigate, but if 6 or 8 weeks can be allowed before planting, DDT will be much more economical. Fumigation kills only those wireworms that are present, whereas DDT remains effective in the soil for several years. If a fumigant is applied, it should be followed within a year with DDT.

PRECAUTIONS

Insecticides are poisonous. Handle them with care. Follow the directions and heed all precautions on the container label.

When handling or mixing concentrated insecticides, avoid spilling them on your skin and keep them out of your eyes, nose, and mouth. If any is spilled, wash it off the skin and change clothing immediately.

Ethylene dibromide is very poisonous to man and animals. It should be handled with every possible precaution and only by individuals thoroughly familiar with its hazards. Do not transfer ethylene dibromide from one container to another in a closed room. Do not breathe the fumes. If you spill ethylene dibromide on your skin, wash it off promptly with soap and water. Remove immediately clothing or shoes that have been wet with the liquid; otherwise, severe blistering will result.

Before treating your soil with an insecticide, make sure that the container label or some reliable source specifies that it is for use as a preplanting treatment for the crop that you intend to plant. Certain treatments before planting specific crops may lead to hazardous resi-

dues in the marketed product. Do not use more than is recommended for the specific crop. Do not apply ethylene dibromide to potato fields in areas where it is a practice to fumigate potatoes after harvest with methyl bromide.

Soil Insecticides

DDT

DDT is toxic to wireworms through contact. In economical dosages it takes several weeks or months of exposure to kill the larger wireworms, but it remains in the soil for several years and continues to kill new broods as they hatch. A single application will clean up an infestation in a season (fig. 8) and prevent reinfestation for several years. It might not prevent all damage to the current season's crop, but should reduce it.

Apply 10 pounds of DDT per acre to the soil surface and then thoroughly mix it with the soil 6 to 9 inches deep (fig. 9). Apply at any time of the year when you can obtain a suitable mix with the soil. Apply the material just before disking under crop residues or cover crops. A 20-inch or larger double disk (fig. 10) pulled with a good-sized tractor will give the necessary mixture of DDT with the soil in one operation, especially if the land is plowed first. If smaller disks only are available, you can obtain a good mixture by disking and then plowing and disking again. *The deeper and more thorough the mix, the more wireworms you will kill.*

DDT can be applied as a spray or as a dust. If you use a spray apply 20 pounds of 50-percent wettable powder or 5 gallons of emulsifiable concentrate (containing 2 pounds of DDT per gallon) per acre. Mix it with 50 to 100 gallons of water or an amount sufficient to suit the equipment. Adjust the boom and nozzles so as to distribute the spray uniformly over the soil surface. If you use a dust apply a 10-percent DDT dust at 100 pounds per acre or the equivalent with a power duster or fertilizer spreader and at a time when climatic conditions are such that the dust can be distributed evenly on the soil surface. In places where custom fertilizers are used, the required quantity of DDT dust or wettable powder can be mixed with the per-acre dosages of fertilizer and broadcast before planting. The 50-percent wettable powder is the most economical formulation to use, but it is not always the easiest to use in sprayers or spreaders. Farmers will have to use the material and method best suited to their equipment. No detrimental effects on plants or soil have been observed from DDT when applied as recommended above. Do not treat the land again until small wireworms appear.

DDT, applied as above, is recommended for use in soil to be planted to beans, broccoli, table beets, sugar beets, brussels sprouts, cabbage, carrots, celery, lettuce, peas, potato, eggplant, kale, onions, peppers, rutabaga, strawberry, sweet corn, tomatoes, and turnip.

Other Soil Insecticides

Chlordane will also control wireworms found on irrigated lands. It kills them faster than DDT, but is more expensive and may not remain effective as long in the soil. Apply chlordane at 10 pounds per acre in the same manner as DDT. Chlordane is recommended in soil to be planted to the following crops: Beans, table beets, sugar beets, broccoli, brussels sprouts, cabbage, cauliflower, celery, cucum-

Figure 8.—Wireworm damage to lima beans controlled with DDT. Top field not treated; lower field treated with DDT 2 months before planting.

Figure 9.—Orchard sprayer equipped with a spray boom for applying DDT on the soil surface for wireworm control.

Figure 10.—A double disk harrow for mixing DDT with wireworm-infested soil.

ber, eggplant, kale, melons, lettuce, onions, peppers, potatoes, rutabaga, strawberry, sweetpotatoes, sweet corn, tomatoes, and turnip.

Heptachlor and **dieldrin** are effective at 3 pounds per acre applied in the same manner as DDT. Heptachlor is recommended in soil to be planted to asparagus, beans, table beets, sugar beets, broccoli, blackberry and other bramble berries, brussels sprouts, cabbage, cauliflower, mint, onions, peas, peppers, potatoes, celery, rutabaga, strawberry, sweetpotatoes, tomatoes, and turnip. Dieldrin is recommended in soil to be planted to asparagus, beans, table beets, broccoli, brussels sprouts, cabbage, cauliflower, celery, cucumber, eggplant, lettuce,

melons, peppers, potatoes, rutabaga, summar squash, endine, kohlrabi, bramble berries, strawberry, sweetpotatoes, tomatoes, and turnip.

Aldrin has not been consistently effective at 3 pounds per acre, against wireworms found on irrigated lands. Aldrin at 4 pounds per acre is recommended for wireworms in soil to be planted to strawberry, sugar beets, and bramble berries.

Lindane and **BHC** are very toxic to wireworms, but they may affect the flavor of potatoes and root crops, and therefore are not recommended for control of wireworms in soils where crops of any kind are to be grown for human food.

Soil Fumigation

Ethylene Dibromide

Ethylene dibromide is a very heavy liquid which, when introduced into the soil, evaporates slowly to form a gas that is highly toxic to wireworms. It is usually sold in an 83-percent solution, or one containing 12 pounds to the gallon. You can use this solution without further dilution in equipment constructed to distribute low dosages (3 to 5 gallons per acre). However, if such equipment is not available, dilute 3 gallons with 7 gallons of any petroleum thinner and apply at 10 gallons per acre. Agitate the mixture thoroughly before using.

Place the ethylene dibromide solution at least 8 inches deep in the soil, as most of the wireworms live from 3 to 15 inches below the surface.

Ethylene dibromide will retard the germination of seed and affect the newly sprouted seedlings. For this reason, do not seed or set plants for at least 3 weeks after fumigation.

In some instances in California, ethylene dibromide has been responsible for excessive rotting of Fordhook 242 lima bean seed when applied within 2 months before planting in soils winter-cropped to lettuce, pepper, and cabbage. This rot condition has not been observed in fields allowed to remain fallow during the winter months.

Ethylene dibromide is recommended for use in soil to be planted to the following crops: Asparagus, lima beans, broccoli, carrots, cauliflower, cucumber, eggplant, lettuce, melons, okra, parsnip, peppers, potatoes, strawberry, summer squash, sweet corn, sweetpotatoes, and tomatoes.

Fumigation Equipment and Methods

For large fields trailing or mounted applicators are very satisfactory (figs. 11 and 12). The liquid fumigant is injected into the soil under pressure by means of a gear pump attached to a manifold to insure equal pressure on all outlets. The pump is operated by the power takeoff shaft of the tractor. Most applicators are equipped with chisel shanks for deep penetration. Tubes welded to the rear of these shanks carry the liquid into the soil and release it through special nozzles, usually made of stainless steel. The number of shanks on applicators ranges from 5 to 14. The usual spacing is 12 inches, but the spacing is adjustable to allow closer or wider application patterns. Applicators have been devised that will apply as little as 3 gallons per acre uniformly, and treat from 10 to 40 acres per day.

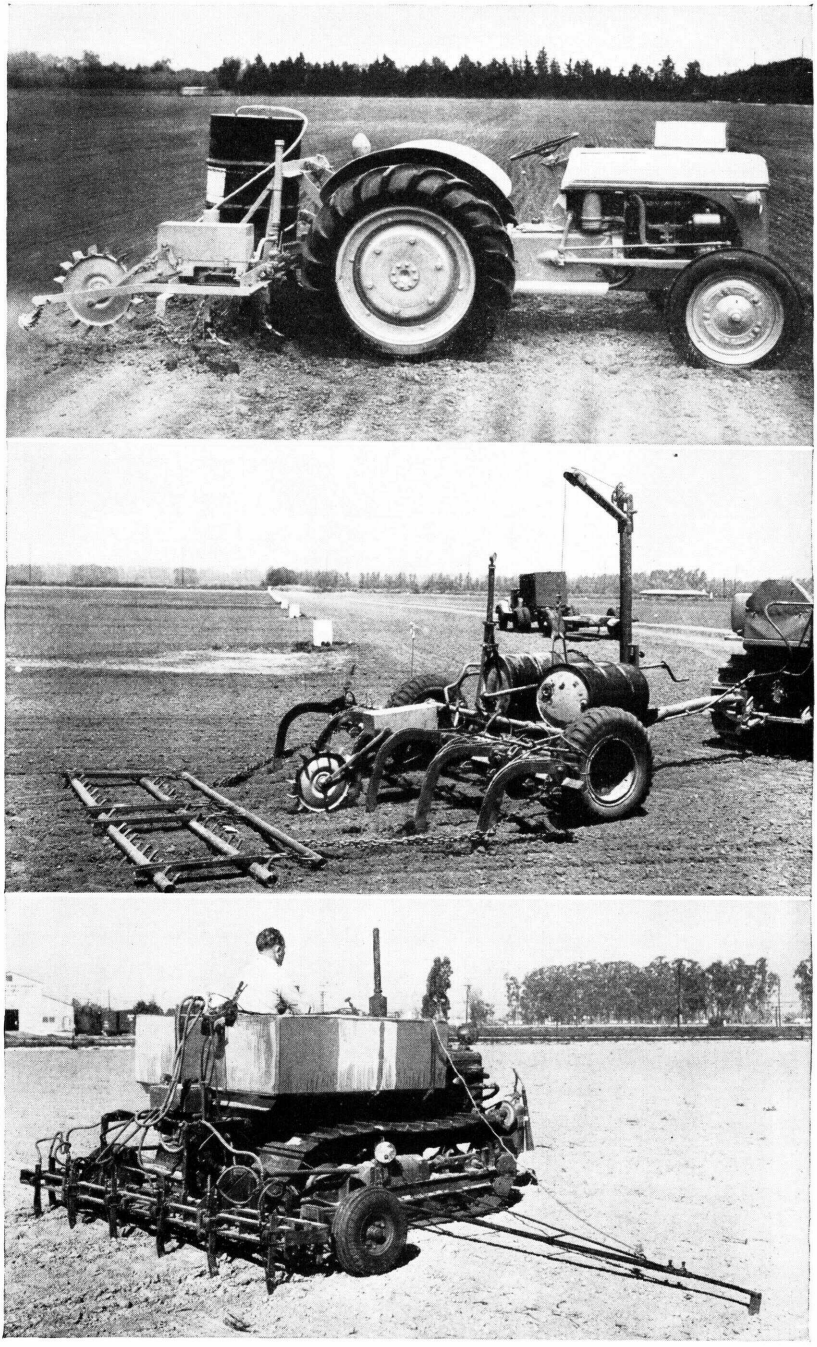

Figure 11.—Applicators used in fumigating wireworm-infested fields.

Plow applicators (fig. 12) may be used for small fields. They can be made up on the farm from a second-hand gasoline tank, some ¼-inch copper tubing, and two or more valves, and attached to the tractor or plow. The fumigant is led by gravity from the storage tank through the tube onto the plowsole just ahead of the plow. There should be needle valves to regulate the flow in the outlet tubes, as well as a shutoff valve (fig. 13).

Since no pressure is applied to the fumigant by this method, 10 gallons per acre is about the smallest amount that can be delivered uniformly with accuracy. The rate of flow must be adjusted to the width of the furrow and the speed of the tractor. The rates of flow necessary to deliver 10 gallons per acre for three furrow widths at several tractor speeds are given below:

Tractor speed[1] (feet per minute)	Fluid ounces per minute		
	12-inch furrow	14-inch furrow	16-inch furrow
250	7½	8½	10
300	9	10	12
350	10	12	14
400	12	13½	15½
450	13	15½	17½
500	14½	17	19½

[1] Eighty-eight feet per minute equals 1 mile per hour.

For areas of less than an acre, the fumigant may be dribbled by hand along the bottom of the furrow when plowing or spading and covered as soon as possible. Since there would be some loss by evaporation with this method, the dosage must be heavier than for the larger fields. To apply 10 gallons per acre use 3 fluid ounces for each 50 feet of furrow, and to reduce evaporation do not expose more furrow than necessary.

Preparation of Soil for Fumigation

For any method of treatment the soil should be in good working condition. Do not apply fumigant when the soil is too wet to work properly or when the soil temperature is below 55° F. at the 6-inch depth. Before making the application plow the soil as deeply as possible to loosen the layer in which the wireworms are present. The soil should be free of heavy plant debris, such as potato or tomato vines or cornstalks, which will be picked up by the machine and cause stalling or poor application. If the soil is cloddy, disk it or cultivate it deeply to break up the clods. If you apply the fumigant in the plowing operation, the amount of plant debris is less important, provided you use a colter to cut the stems and turn the debris completely under.

Soil Treatment After Fumigation

Immediately after fumigation the soil should be cultivated shallowly but thoroughly to seal the surface. If a heavy tractor is used, the surface may be sealed in the same operation as the fumi-

gation by pulling behind the applicator a light spike-tooth harrow followed by a heavy steel bar.

Figure 12.—Two-way plow applicator, showing fumigant tank with tubes leading to the furrow.

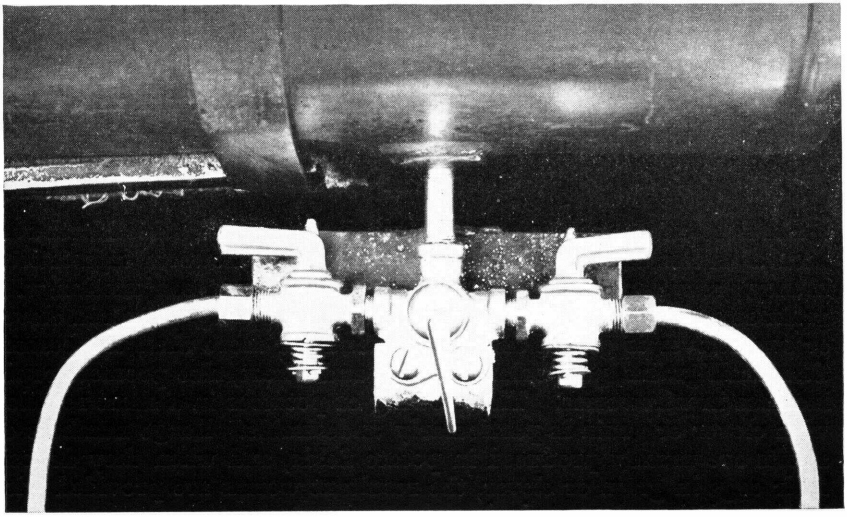

Figure 13.—Center three-way shutoff valve and two calibrating valves used under tank with two-way plow applicator.

CULTURAL METHODS OF CONTROL

Cultural methods of wireworm control are based on the behavior of the wireworms under various soil conditions and farm practices. In the Pacific Northwest, where studies were carried on for over 10 years, it was found that farmers can often avoid serious wireworm damage to their crops by systematic crop rotation and the right cultural methods.

Water Use

Neither the temperature nor the moisture normally found in irrigated soils is detrimental to wireworms. However, when either too much or too little moisture is combined with high temperatures, wireworms are greatly reduced in number. Flooding infested fields for 6 to 7 days with an inch or two of water during extremely hot weather will kill nearly all the wireworms. Soil temperatures under the water must remain above 68° F. for the entire period for best results. In contrast, when the upper 15 inches of infested soil is allowed to become very dry for several weeks in the summer, most of the wireworms, especially the younger ones, are killed.

If soil drying can be fitted into crop rotation so that heavily infested fields can be dried once every 5 or 6 years, wireworm populations can be kept below the number that will cause commercial damage. Drying of the soil to kill wireworms can best be accomplished by withholding irrigation water from good stands of alfalfa or fall grain just before it is harvested. Drying is most effective on first- and second-year wireworms in sandy to silt-loam soils, but many larger wireworms are killed by this method.

Cultivation

Wireworm numbers can also be reduced by plowing infested fields in summer during the pupal stage. Mechanical injury to the worms and exposure to summer heat and low humidities account for most of the mortality at this stage. If you plow fields that have been in small grain or early truck crops between July 15 and August 15, you will materially reduce the number of adult wireworms that will lay eggs the following spring.

Rotation of Crops

Farmers on the newer irrigation projects of the Pacific Northwest should understand the danger of developing wireworm infestations if they grow clover for seed or forage, especially in conjunction with grain as a nurse crop. Wireworms increase rapidly when red clover or sweetclover is grown on infested land for more than one season. The small grains, particularly barley and wheat, also promote rapid increase in wireworms. The growing of potatoes in a short rotation with clover or grain is particularly undesirable. Large numbers of adults are usually produced in potato fields, and when they deposit their eggs in grain or clover, the resultant worms are provided with ideal conditions for survival.

In contrast with red clover or sweetclover, alfalfa creates a dry, compact soil condition which is unfavorable to wireworms. Maintaining a good stand of alfalfa in a clean, thrifty condition for 3 or 4 years on well-drained land usually results in a reduction of heavy infestations. Alfalfa is not a favorable food for wireworms, and fewer adults are produced in alfalfa fields. The beneficial effects of growing alfalfa as a control for wireworms can be greatly increased in some districts by omitting the irrigation of the first cutting each year, thereby preventing the survival of the new-brood wireworms.

Pasture sod, if maintained for several years, also is detrimental to the irrigated-land wireworms of the Pacific Northwest. The practice, in some districts, of flooding pastures sometime during the spring and summer often reduces the deposition of eggs and kills the younger wireworms.

The best rotation for keeping wireworms at a low level is 3 or 4 years of alfalfa followed by 1 year of potatoes and 1 or 2 years of other truck crops, such as sugar beets, corn, beans, or peas. The growing of truck crops continuously in the same soil will usually increase wireworm numbers until the use of chemical or cultural control measures becomes necessary.

U. S. GOVERNMENT PRINTING OFFICE: 1959

CHECK up on these accident hazards around your farm . . .

√ Is farmyard clear of tools, broken glass, loose strands of barbed wire, nail-studded boards?

√ Are water tanks, cisterns, and wells protected?

√ Are ladders and steps in good repair?

√ Are pitchforks, rakes, shovels, and other sharp tools kept in racks?

√ Are electric circuits and appliances in good condition?

√ Is unused lumber carefully stacked?

√ Are buildings and fences in good repair?

clean up your farm

to make it attractive and SAFE